

## § 1033.520

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measure PM emissions as specified in paragraph (d)(2)(ii) of this section.

(ii) You may use a single PM filter for sampling PM over all of the test modes of the locomotive test cycle as specified in this paragraph (d)(2). Vary the sample time to be proportional to the applicable line-haul or switch weighting factors specified in § 1033.530 for each mode. The minimum sampling time for each mode is 400 seconds multiplied by the weighting factor. For example, for a mode with a weighting factor of 0.030, the minimum sampling time is 12.0 seconds. PM sampling in each mode must be proportional to engine exhaust flow as specified in 40 CFR part 1065. Begin proportional sampling of PM emissions at the beginning of each test mode as is specified in paragraph (c) of this section. End the sampling period for each test mode so that sampling times are proportional to the weighting factors for the applicable duty cycles. If necessary, you may extend the time limit for each of the test modes beyond the sampling times in Table 1 to this section to increase the sampled mass of PM emissions or to account for proper weighting of the PM emission sample over the entire cycle, using good engineering judgment.

(e) This paragraph (e) describes how to test locomotive engines when not installed in a locomotive. Note that the test procedures for dynamometer engine testing of locomotive engines are intended to produce emission measurements that are the same as emission measurements produced during testing of complete locomotives using the same engine configuration. The following requirements apply for all engine tests:

(1) Specify a second-by-second set of engine speed and load points that are representative of in-use locomotive operation for each of the set-points of the locomotive test cycle described in Table 1 to this section, including transitions from one notch to the next. This is your reference cycle for validating your cycle. You may ignore points between the end of the sampling period for one mode and the point at which you change the notch setting to begin the next mode.

(2) Keep the temperature of the air entering the engine after any charge air cooling to within 5 °C of the typical intake manifold air temperature when the engine is operated in the locomotive under similar ambient conditions.

(3) Proceed as specified in paragraphs (a) through (d) of this section for testing complete locomotives.

[73 FR 37197, June 30, 2008, as amended at 73 FR 59190, Oct. 8, 2008; 74 FR 8424, Feb. 24, 2009; 75 FR 22985, Apr. 30, 2010]

### § 1033.520 Alternative ramped modal cycles.

(a) Locomotive testing over a ramped modal cycle is intended to improve measurement accuracy at low emission levels by allowing the use of batch sampling of PM and gaseous emissions over multiple locomotive notch settings. Ramped modal cycles combine multiple test modes of a discrete-mode steady-state into a single sample period. Time in notch is varied to be proportional to weighting factors. The ramped modal cycle for line-haul locomotives is shown in Table 1 to this section. The ramped modal cycle for switch locomotives is shown in Table 2 to this section. Both ramped modal cycles consist of a warm-up followed by three test phases that are each weighted in a manner that maintains the duty cycle weighting of the line-haul and switch locomotive duty cycles in § 1033.530. You may use ramped modal cycle testing for any locomotives certified under this part.

(b) Ramped modal testing requires continuous gaseous analyzers and three separate PM filters (one for each phase). You may collect a single batch sample for each test phase, but you must also measure gaseous emissions continuously to allow calculation of notch caps as required under § 1033.101.

(c) You may operate the engine in any way you choose to warm it up. Then follow the provisions of 40 CFR part 1065, subpart F for general pre-test procedures (including engine and sampling system pre-conditioning).

(d) Begin the test by operating the locomotive over the pre-test portion of the cycle. For locomotives not equipped with catalysts, you may begin the test as soon as the engine reaches

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its lowest idle setting. For catalyst-equipped locomotives, you may begin the test in normal idle mode if the engine does not reach its lowest idle setting within 15 minutes. If you do start in normal idle, run the low idle mode after normal idle, then resume the specified mode sequence (without repeating the normal idle mode).

(e) Start the test according to 40 CFR 1065.530.

(1) Each test phase begins when operator demand is set to the first operator demand setting of each test phase of the ramped modal cycle. Each test phase ends when the time in mode is reached for the last mode in the test phase.

(2) For PM emissions (and other batch sampling), the sample period over which emissions for the phase are averaged generally begins within 10 seconds after the operator demand is changed to start the test phase and ends within 5 seconds of the sampling time for the test mode is reached. (see Table 1 to this section). You may ask to delay the start of the sample period to account for sample system residence times longer than 10 seconds.

(3) Use good engineering judgment when transitioning between phases.

(i) You should come as close as possible to simultaneously:

(A) Ending batch sampling of the previous phase.

(B) Starting batch sampling of the next phase.

(C) Changing the operator demand to the notch setting for the first mode in the next phase.

(ii) Avoid the following:

(A) Overlapping batch sampling of the two phases.

(B) An unnecessarily long delay before starting the next phase.

(iii) For example, the following sequence would generally be appropriate:

(A) End batch sampling for phase 2 after 240 seconds in notch 7.

(B) Switch the operator demand to notch 8 one second later.

(C) Begin batch sampling for phase 3 one second after switching to notch 8.

(4) If applicable, begin the smoke test at the start of the first test phase of the applicable ramped modal cycle. Continue collecting smoke data until the completion of final test phase. Refer to §1033.101 to determine applicability of the smoke standards and §1033.525 for details on how to conduct a smoke test.

(5) Proceed through each test phase of the applicable ramped modal cycle in the order specified until the test is completed.

(6) If you must void a test phase you may repeat the phase. To do so, begin with a warm engine operating at the notch setting for the last mode in the previous phase. You do not need to repeat later phases if they were valid. (NOTE: you must report test results for all voided tests and test phases.)

(7) Following the completion of the third test phase of the applicable ramped modal cycle, conduct the post sampling procedures specified in 40 CFR 1065.530.

(f) Calculate your cycle-weighted brake-specific emission rates as follows:

(1) For each test phase j:

(i) Calculate emission rates ( $E_{ij}$ ) for each pollutant i as the total mass emissions divided by the total time in the phase.

(ii) Calculate average power ( $P_j$ ) as the total work divided by the total time in the phase.

(2) For each pollutant, calculate your cycle-weighted brake-specific emission rate using the following equation, where  $w_j$  is the weighting factor for phase j:

$$E_{ij} = \frac{w_1 E_{i1} + w_2 E_{i2} + w_3 E_{i3}}{w_1 P_1 + w_2 P_2 + w_3 P_3}$$

(g) The following tables define applicable ramped modal cycles for line-haul and switch locomotives:

TABLE 1 TO § 1033.520—LINE-HAUL LOCOMOTIVE RAMPED MODAL CYCLE

RMC test phase	Weighting factor	RMC mode	Time in mode (seconds)	Notch setting
Pre-test idle	NA	NA	600 to 900	Lowest idle setting <sup>1</sup>
Phase 1		A	600	Low Idle. <sup>2</sup>

TABLE 1 TO § 1033.520—LINE-HAUL LOCOMOTIVE RAMPED MODAL CYCLE—Continued

RMC test phase	Weighting factor	RMC mode	Time in mode (seconds)	Notch setting
Pre-test idle	NA	NA	600 to 900	Lowest idle setting <sup>1</sup>
(Idle test) .....	0.380	B	600	Normal Idle.
Phase Transition				
Phase 2 .....	0.389	C 1 2 3 4 5	1000 520 520 416 352 304	Dynamic Brake. <sup>3</sup> Notch 1. Notch 2. Notch 3. Notch 4. Notch 5.
Phase Transition				
Phase 3 .....	0.231	6 7 8	144 111 600	Notch 6. Notch 7. Notch 8.

<sup>1</sup> See paragraph (d) of this section for alternate pre-test provisions.

<sup>2</sup> Operate at normal idle for modes A and B if not equipped with multiple idle settings.

<sup>3</sup> Operate at normal idle if not equipped with a dynamic brake.

TABLE 2 TO § 1033.520—SWITCH LOCOMOTIVE RAMPED MODAL CYCLE

RMC test phase	Weighting factor	RMC mode	Time in mode (seconds)	Notch setting
Pre-test idle	NA	NA	600 to 900	Lowest idle setting <sup>1</sup>
Phase 1 (Idle test) .....	0.598	A B	600 600	Low Idle. <sup>2</sup> Normal Idle.
Phase Transition				
Phase 2 .....	0.377	1 2 3 4 5	868 861 406 252 252	Notch 1. Notch 2. Notch 3. Notch 4. Notch 5.
Phase Transition				
Phase 3 .....	0.025	6 7 8	1080 144 576	Notch 6. Notch 7. Notch 8.

<sup>1</sup> See paragraph (d) of this section for alternate pre-test provisions.

<sup>2</sup> Operate at normal idle for modes A and B if not equipped with multiple idle settings.

[73 FR 37197, June 30, 2008, as amended at 74 FR 8424, Feb. 24, 2009]

#### § 1033.525 Smoke testing.

This section describes the equipment and procedures for testing for smoke emissions when is required.

(a) This section specifies how to measure smoke emissions using a full-flow, open path light extinction smokemeter. A light extinction meter consists of a built-in light beam that traverses the exhaust smoke plume that issues from exhaust the duct. The light beam must be at right angles to

the axis of the plume. Align the light beam to go through the plume along the hydraulic diameter (defined in 1065.1001) of the exhaust stack. Where it is difficult to align the beam to have a path length equal to the hydraulic diameter (such as a long narrow rectangular duct), you may align the beam to have a different path length and correct it to be equivalent to a path length equal to the hydraulic diameter. The light extinction meter must meet the requirements of paragraph (b) of this section and the following requirements: